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FINAL REPORT

VELA UNIFORM

PROJECT SHOAL

SPONSORED BY THE ADVANCED RESEARCH PROJECTS AGENCY OF THE
DEPARTMENT OF DEFENSE AND THE U. S. ATOMIC ENERGY COMMISSION

FALLON, NEVADA
OCTOBER 26, 1963

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FINAL REPORT OF OFF-SITE SURVEILLANCE

Southwestern Radiological Health Laboratory

September 1, 1964

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VUF-1009

FINAL REPORT OF OFF-SITE SURVEILLANCE

by the
Off-Site Radiological Safety Program
Southwestern Radiological Health Laboratory
Las Vegas, Nevada

for
Operational Safety Division
Nevada Operations Office
Atomic Energy Commission

September 1, 1964

Department of Health, Education, and Welfare
Public Health Service

ABSTRACT

Project Shoal, which took place at a location near Fallon, Nevada on October 26, 1963 at 1000 PDT, was an underground nuclear detonation conducted as a part of the Vela program of the Department of Defense. The Off-Site Radiological Safety Program of the U.S. Public Health Service's Southwestern Radiological Health Laboratory monitored the public area surrounding the site and collected and analyzed several hundred water, milk, and air samples before and for several weeks after the event. Analysis of these samples indicated that the radioactive material from the Shoal event was completely contained. During post-shot drilling operations an intermittant release of gaseous material containing fresh fission products occurred, but was not detected on air samplers located in populated areas or in milk and water samples taken since that time.

PROJECT SHOAL

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SOUTHWESTERN RADIOLOGICAL HEALTH LABORATORY

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TABLE OF CONTENTS

ABSTRACT i

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TABLE OF CONTENTS iii

INTRODUCTION 1

METHODOLOGY 4

Field Procedures 6

Instrumentation 8

Laboratory Procedures 11

RESULTS 15

Monitoring 15

Dosimetry 15

Sampling 15

POST-SHOT DRILLING OPERATIONS 16

CONCLUSION 16

APPENDIX SAMPLING LOCATIONS AND MILK SAMPLING RESULTS FOR PROJECT SHOAL 17

Figure 1. Sampling locations during Project Shoal. 17

Table 1. Milk sample analysis. 18

Table 2. Samples taken for Project Shoal. 22

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INTRODUCTION

Project Shoal was a contained 12 kiloton nuclear explosion conducted as a part of the Vela program of the Department of Defense to improve the capability of detecting, locating, and identifying underground nuclear detonations. The Shoal detonation took place 1200 feet underground in granite at a location near Fallon, Nevada on October 26, 1963.

The Off-Site Radiological Safety Program of the U.S. Public Health Service's Southwestern Radiological Health Laboratory in Las Vegas, Nevada conducted a program of off-site radiological surveillance and safety for Project Shoal. Authorization for this program was established by Memorandum of Understanding No. SF 54 373 between the Atomic Energy Commission (AEC) and the Public Health Service (PHS). Chapter 0524-05, "Off-Site Rad Safety Operations" of the Standard Operating Procedure - Nevada Test Site Organization outlines in detail the responsibilities of the PHS to the Nevada Test Site Organization and the procedures to be used in fulfilling these responsibilities. Briefly, these responsibilities were:

1. Verify the off-site radiological situation associated with

test activities to insure public safety. For Project Shoal, off-site was defined as extending from a radius of five miles out to a distance of fifty miles from Ground Zero. Should a release of radioactive material occur, this area would be extended as far as necessary to properly evaluate the situation.

2. Maintain a staff of trained personnel available to take emergency measures prescribed by the Atomic Energy Commission, should an unacceptable radiological situation develop.

3. Obtain an adequate record of radioactive contaminants released to the off-site area.

4. Maintain public confidence that all reasonable safeguards are being employed to protect public health and property.

5. Establish liaison with various local and state officials concerning radiological health within their administrative areas.

6. Investigate reports of incidents attributed to radioactivity.

7. Accumulate and process data to provide a basis for evaluating cumulative radiation dose to people.

The PHS began its pre-shot surveillance as early as July 1963. Air sampling stations were established at seven locations in the area from which 24-hour samples were taken daily. An extensive public relations program was effected before the event. Lectures,

demonstrations, and movies were presented at Lions Clubs, Rotary Clubs, Veterans of Foreign Wars and American Legion groups, and at schools in the off-site area. A close working relationship was established with news media in the Fallon, Nevada area.

Sampling and monitoring activities were intensified early in October, and they reached a peak just before, and for a few weeks after, the detonation. They were continued, although at a less intense level, throughout post-shot drilling operations. Frequency and density of sampling was then gradually decreased with time to the date of this report (June 15, 1964), when seven air sampling stations are still in operation, and milk and water are being collected routinely from a few off-site locations.

Although the Shoal detonation did not release radioactive material to the off-site area, and no radioactivity greater than normal background levels was detected in this area during or after the re-entry drilling operations, this report will describe the organization, methodology, and instrumentation used and the coverage provided by the program of off-site radiological surveillance.

METHODOLOGY

In general, monitoring and sampling methods, field procedures, laboratory procedures, and program coordination and control were similar to those previously reported for Off-Site Radiological Safety Program activities. However, because Project Shoal was located at a site other than the Nevada Test Site, some special arrangements were made.

Two PHS personnel were assigned to the project officer for pre-shot activities. They were responsible for establishing air sampling stations, selecting milk and water collection points, and conducting the preliminary public relations work. They were assisted in making road surveys in the area by four PHS Reserve Corps Officers. By September 10, 1963, a total of twelve Reserve Officers were assigned in the Fallon area to Project Shoal. On the day of the event, about forty-five PHS personnel were on duty at the Control Point and in the areas off site.

A mobile Radioassay Laboratory, maintained by SWRHL as a field counting laboratory, was moved to Fallon to provide temporary facilities close to the site for counting gross alpha and

gross beta activity and for gamma spectrometry. The PHS laboratories in Las Vegas provided technicians and facilities for all but preliminary analyses of air, water, and milk samples. They also processed and analyzed samples of water collected for Project Shoal by the Desert Research Institute of the University of Nevada.

A whole body counter on a railroad flatcar, designed and constructed by the Technical Operations Branch, Division of Radiological Health, PHS, was moved to Fallon for support of Project Shoal. There it was set up with an ambulance car which housed electronics and preparation facilities. The detector assembly consisted of two 1.5 inch by 1.5 inch and one 11 inch by 4 inch NaI(Tl) crystals. They were housed in an 8 foot by 8 foot steel room having walls 6 inches thick composed of laminated steel plates. The subject being counted lay on a steel-framed bed mounted on tracks laid down the center of the room. The two small crystals were mounted on the bed to view the two lobes of the thyroid gland. The large, separately mounted crystal was placed in a standard position over the body mid-line.

Technicians from SWRHL calibrated this equipment for determination of I^{131}, Cs^{137}, and K^{40}. The whole body counting

activities were directed by a Medical Officer assigned from PHS headquarters in Washington, D. C.

PHS physicians were assigned to Fallon and were present before, during and after the event. Close contact between PHS doctors and local physicians was established and the medical aspects of the testing program were discussed in detail.

A U.S. Army Veterinary Officer and a PHS veterinarian contacted local veterinarians and made trips to several of the ranches and farms in the area to discuss the program and to explain the veterinary services that would be available if a problem should develop.

Field Procedures

The basic working unit for radiation monitoring and environmental sampling for Project Shoal was the one- or two-man mobile monitoring team equipped with various survey instruments, sampling apparatus, tools, and supplies. These teams worked from radio-equipped pickup trucks which served as mobile stations in a communications network through which they were in constant radio contact with directive personnel at the Shoal Control Point and the laboratory staff at the Fallon headquarters.

Before the Shoal "D" Day, these monitoring teams placed numbered location signs on dirt roads throughout the areas downwind of Ground Zero to the east and southeast for monitoring reference points. They also took dose rate readings in the off-site areas to determine pre-shot radiation background.

The pre-shot dose rate surveys, as well as post-shot surveys, were made by the standard monitoring procedure where the detector or probe is held three feet above ground level at a reasonable distance from any heavily contaminated or radioactive artifact. The location and time, as well as the magnitude of each dose rate measurement, are recorded on a monitoring log, on which is also recorded the survey instrument and vehicle numbers.

On the day of the Shoal detonation, the ground monitoring teams carried portable gasoline generators and extra sampling gear with which the activated sampling network could be supplemented if necessary. After the event, it was these teams who collected samples, exchanged film badges, and maintained the sampling network throughout post-shot drilling operations.

On D-day the mobile ground monitors were assisted by an aerial monitoring team in a Public Health Service C-45 aircraft.

This crew and stand-by crews had made several flights over the Shoal site and the areas off site on D minus 1 to orient themselves and to become familiar with the area as viewed from the air. If a release of radioactive material had occurred, this team would have monitored and tracked the resulting "cloud" from the air, radioing information as to cloud position, size, and direction and rate of travel to directive personnel at the Control Point. Mobile ground teams would then be more accurately positioned to measure the dose rate three feet above ground produced by passage of the cloud or by deposition of material from it.

Instrumentation

Four types of survey instruments were carried by ground monitoring teams enabling them to monitor dose rates from background levels of approximately 0.02 milliroentgens per hour up to 200 milliroentgens per hour from beta plus gamma radiation, or up to 50 roentgens per hour from gamma radiation alone. These were the Precision Model 111 Standard "Scintillator" which has an external probe containing a sodium iodide crystal detector, the Eberline E-500B Geiger detector with external probe and beta shield, the Beckman Model MX-5 Geiger detector having a probe similar to the E-500B, and the Tracerlab AN/PDR T1B

ionization chamber detector. Dose rates detected by these survey instruments can be read to two significant figures.

These same survey instruments were carried by the aerial monitoring team along with the Portable Aerial Survey Meter SBL-2 manufactured by Edgerton, Germeshausen, and Grier, Inc. The SBL-2 consists of a transistorized, battery operated, portable scintillation detector and recorder. It can be used for either ground or aerial surveys under a variety of environmental conditions, and is sensitive to dose rates from 0.2 to 2000 milliroentgens per hour.

DuPont type 556 film badge dosimeters were used for Project Shoal surveillance. These badges contain a low range film component, number 508, sensitive to exposures of 0.03 to 5.0 roentgens, and a high range component, number 834, sensitive to exposures of 3.0 to 1000 roentgens. The sensitivity range of the dosimeter is thus 30 mr to 1000 R. For Project Shoal, the badges were supplied and read by the Radiation Safety Department of Reynolds Electrical and Engineering Company, Inc.

Air sampling apparatus consisted of Staplex Company or General Metal Works high volume air samplers. Airborne particulate

material was collected on Gelman type E glass fiber filters which are designed to have a collection efficiency of 99.6% for particles greater than 0.25 microns in diameter, and 98% for 0.05 micron particles. The 8 inch by 10 inch filters were held in commercially available heads which provided an effective sampling area of 63 square inches. Flow rates of 50 to 60 cubic feet per minute were obtained with the filter in place.

The throat of the motor housing of each sampler was machined to accept a 3-1/4 inch diameter activated charcoal cartridge made by Mine Safety Appliances Company. With the cartridge in place behind the glass fiber filter, air flow rates of approximately 20 to 30 cubic feet per minute were obtained. Actual flow rate for each sample was determined from rotameter readings taken at the beginning and end of the sampling period.

One gallon samples of milk and of water were collected for analysis. The polyethylene collection bottles were also used for shipping samples to the laboratory in order to reduce the possibility of contaminating them during transfer from one container to another.

Laboratory Procedures

Gross beta activity of the airborne particulate material collected on glass fiber filters was determined by counting the filter in a large area gas flow proportional probe connected to a high speed scaler. A counting efficiency (counts per disintegration) of approximately thirty percent was obtained with this system, based on a strontium-yttrium-90 standard. Charcoal cartridges were examined for gamma-emitter activity by gamma pulse height analysis, using a heavily shielded 4 inch by 4 inch NaI(Tl) crystal detector coupled to a multi-channel analyzer. The charcoal cartridge, sealed in a thin plastic bag, was centered on the crystal to give a constant geometry. Using a peak width of 90 kev, a counting efficiency of 12% for the 0.36 Mev photopeak of I^{131} was obtained.

Standard procedure calls for submitting filter samples with high gross beta activity to gamma spectrum analysis. The 8 inch by 10 inch filter is folded in eighths and placed on the sodium iodide detector to approximate the geometry of the charcoal cartridges.

Water and milk samples were analyzed for gamma emitting isotopes in the same crystal - spectrometer system used for air

samples. One-gallon samples were scanned in inverted well beakers placed over the crystal. If sample volume was too small to permit this geometry, a 400 milliliter aliquot was placed in a plastic "cottage cheese tub" container and centered on the crystal. Detection efficiencies for the 0.36 Mev photopeak of I^{131} were approximately 6.5% in the beaker and 7.2% in the cheese tub configuration.

Samples collected during the detonation and re-entry operations of Project Shoal were counted in the mobile Radioassay Laboratory in Fallon as soon after collection as possible. In this way the presence of any unusual activity could be detected, and action could be taken immediately. After the initial counts were made, the samples were sent to the Las Vegas laboratory for further counting and analysis. Samples collected during non-operational periods were sent directly to the main laboratory of SWRHL.

At the Las Vegas laboratory, gross beta activity on air filter samples was determined five days after collection to allow for decay of natural radioactivity. They were again counted twelve days after collection, and the usual $t^{-1.2}$ extrapolation was made to correct activity counted to activity at the end of the collection

period.

Milk samples were analyzed radiochemically to determine the concentration of strontium-89, strontium-90, and stable calcium. Total strontium was chemically isolated and counted in a low background beta counter, as was the yttrium daughter of strontium-90. Strontium-89 was determined by the difference between total strontium and strontium-90, as calculated from the equilibrium value of its yttrium-90 daughter. Detection efficiency for strontium-90 and yttrium-90 was approximately 35%.

Water samples were filtered through Whatman No. 42 filter paper to separate suspended and dissolved solids. Each fraction, after being transferred to a planchet and dried by appropriate means, was counted for gross alpha and for gross beta activity.

Gamma-emitting isotopes detected qualitatively in the spectral scan were quantitated by the laboratory's standard matrix method which corrects for mutual interference between isotopes. If short-lived isotopes are detected for which standards cannot be obtained, a quantitative estimate can be made by scanning the samples several times to obtain the decay patterns of various

regions of the spectrum. When neither method is applicable, the routine procedure involves smoothing the spectrum under each photopeak and subtracting this portion from total peak activity as a gross approximation of the contribution from background and scattering.

RESULTS

Monitoring

Seventeen ground monitoring teams took periodic readings from the time of detonation to late in the afternoon on the day of the event. No readings above background were obtained. Aerial monitoring was performed from several hours before detonation until sundown. The PHS aerial monitoring team obtained no readings above background.

Dosimetry

No exposures greater than the detection limit of 30 mr were read on the personnel and station film badges. The whole body counter, used in support of Project Shoal, tested forty-one subjects, including all PHS monitors, from October 21, 1963 until December 5, 1963. Iodine-131 was not detected in any subject.

Sampling

All glass fiber filters from air samplers were at background levels during and after the event. The charcoal cartridges from air samplers were analyzed for gamma emitters and no fresh fission products were found. Analyses of milk and water samples collected since the event have given no indication of the presence of fresh fission products.

POST-SHOT DRILLING OPERATIONS

During re-drilling operations on December 10, small amounts of gaseous material containing fresh fission products were released into the atmosphere. This release continued intermittently through December 19. No fresh fission products were found on filters or charcoal cartridges taken from air samplers at off-site sampling locations. Milk and water samples taken since the release have been analyzed and found to contain no fresh fission products.

CONCLUSION

Because the Shoal detonation was completely contained, and because the release of fission products during post-shot operations was not detected off-site, it is concluded that there was no health hazard to the off-site population due to Project Shoal.

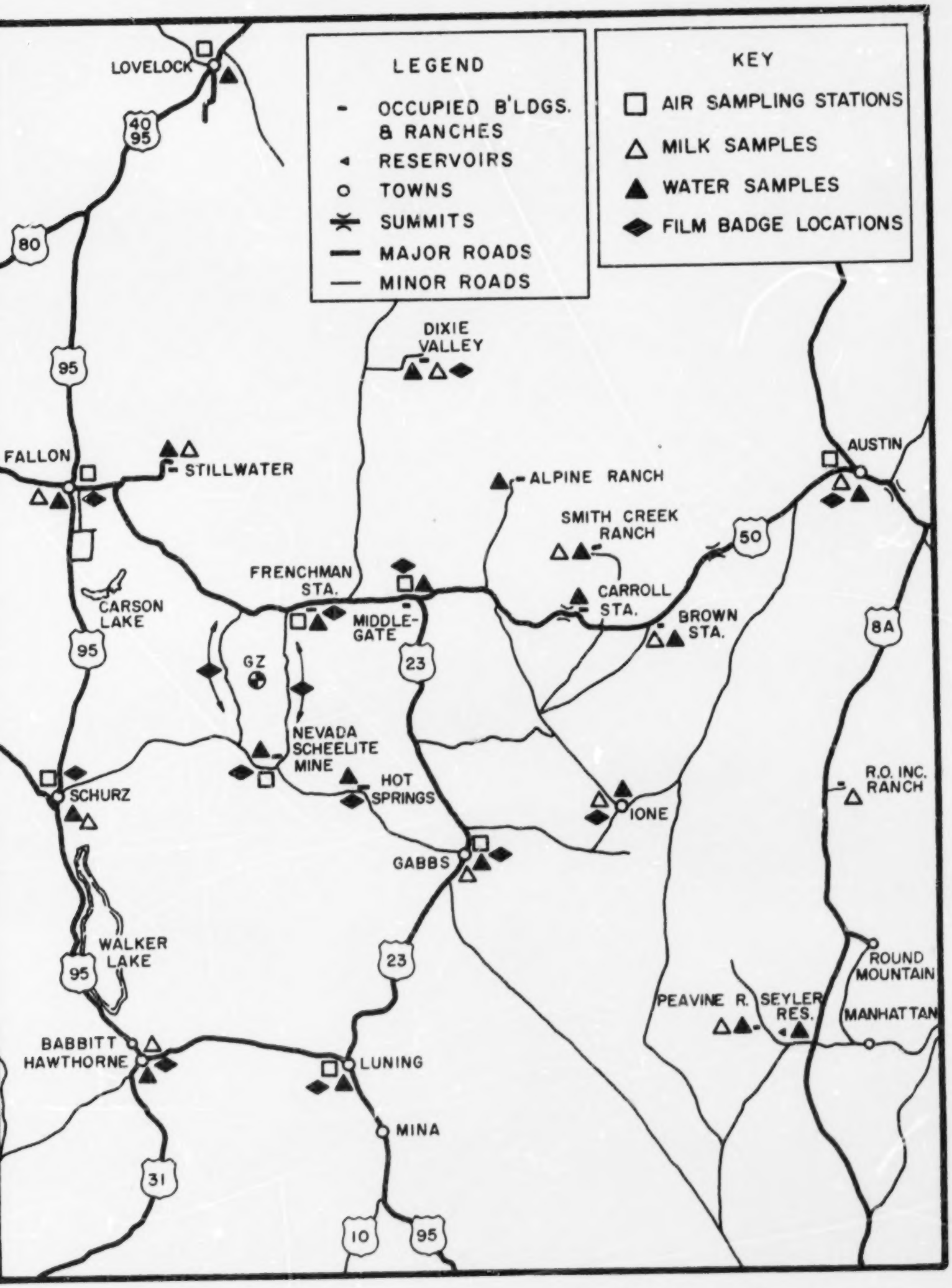

Figure 1. Sampling locations during Project Shoal.

Table 1. Milk sample analysis.

COLLECTION DATA		RADIOCHEMICAL DATA						
		ACTIVITY (pc l)					CONCENTRATION(gm l)	
LOCATION	DATE COLLECTED	Sr^{89}	Sr^{90}	I^{131}	Ba-La^{140}	Cs^{137}	Ca	K
Triple T Ranch, Austin, Nevada	10/17/63	5	35	<10	<10	50	1.26	1.9
	10/24/63	5	35	<10	<10	215	1.26	1.7
	10/31/63	5	15	<10	<10	285	1.33	1.8
L. Streshley, Austin, Nevada	10/17/63	20	36	<10	<10	145	1.43	1.9
	10/24/63	20	36	<10	<10	150	1.43	1.7
	10/31/63	20	32	<10	<10	270	1.10	1.6
Brown Station, Nevada	10/25/63	5	23	<10	<10	120	1.36	1.7
	11/01/63	<5	4	<10	<10	180	1.23	1.7
Crazy K Ranch, Dixie Valley, Nevada	10/17/63	10	14	<10	<10	<5	1.25	2.2
	10/23/63	10	14	<10	<10	35	1.25	1.2
	10/31/63	15	18	<10	<10	85	1.21	1.5
	01/31/64	5	38	<10	<10	165	1.34	1.1
Oats Farm, Fallon, Nevada	10/17/63	35	51	<10	<10	440	1.34	2.0
	10/23/63	35	51	<10	<10	320	1.34	0.9
	10/31/63	45	47	<10	<10	365	1.19	1.4
	01/29/64	5	5	<10	<10	35	1.22	1.6
	04/01/64	5	37	<10	<10	420	1.23	1.6
Charles Frey, Fallon, Nevada	10/17/63	35	34	<10	<10	265	1.23	1.7
	10/23/63	35	34	<10	<10	285	1.23	1.1
	10/31/63	25	39	<10	<10	310	1.18	1.6

Table 1. Milk sample analysis. (Cont.)

COLLECTION DATA		RADIOCHEMICAL DATA						
		ACTIVITY (pc./l)					CONCENTRATION(gm./l)	
LOCATION	DATE COLLECTED	Sr^{89}	Sr^{90}	I^{131}	Ba-La^{140}	Cs^{137}	Ca	K
Farrington Ranch, Gabbs, Nevada	10/18/63	20	13	<10	<10	110	1.10	1.3
	10/24/63	20	13	<10	<10	110	1.10	1.3
	10/31/63	25	38	<10	<10	225	1.32	1.5
A. Jackson, Hawthorne, Nevada	10/17/63	5	6	<10	<10	<5	1.47	2.5
	10/23/63	5	6	<10	<10	10	1.47	1.8
	10/30/63	5	12	<10	<10	<5	1.48	1.7
	02/01/64	5	27	<10	<10	100	1.47	1.7
	04/02/64	15	30	<10	<10	130	1.57	1.5
Mrs. O'Toole, Ione, Nevada	10/17/63	<5	31	<10	<10	120	1.36	1.8
	10/23/63	5	17	<10	<10	70	1.32	1.4
	10/30/63	10	31	<10	<10	145	1.05	1.7
Peavine Ranch, Nevada	10/01/63	35	30	<10	<10	330	1.20	1.6
	10/09/63	20	30	<10	<10	215	1.30	1.7
	10/14/63	15	20	<10	<10	130	1.35	1.5
	10/17/63	15	23	<10	<10	100	1.25	1.9
	10/21/63	25	25	<10	<10	245	1.19	1.5
	10/24/63	15	23	<10	<10	255	1.25	1.2
	10/28/63	25	33	<10	<10	270	1.48	1.3
	10/28/63	25	31	<10	<10	265	1.18	1.6
	10/31/63	25	32	<10	<10	295	1.19	1.7
	11/04/63			<10	<10	310		1.5

Table 1. Milk sample analysis. (Cont.)

COLLECTION DATA		RADIOCHEMICAL DATA						
		ACTIVITY (pc/l)					CONCENTRATION(gm/l)	
LOCATION	DATE COLLECTED	Sr^{89}	Sr^{90}	I^{131}	Ba-La^{140}	Cs^{137}	Ca	K
Peavine Ranch, Nevada (Cont.)	11/11/63	30	33	<10	<10	315	1.27	1.5
	12/01/63	15	23	<10	<10	215	1.27	1.7
	01/04/64	<5	5	<10	<10	75	1.05	1.7
	02/03/64	10	31	<10	<10	345	1.26	1.3
	03/05/64	<5	6	<10	<10	95	1.25	1.5
	04/29/64	5	5	<10	<10	45	1.38	1.5
	06/03/64	10	5	<10	<10	80	1.52	1.3
R.O. Ranch, Nevada	10/17/63	15	17	<10	<10	<5	1.37	2.2
	10/24/63	15	17	<10	<10	20	1.37	1.8
	10/31/63	20	36	<10	<10	50	1.41	1.7
Alvin Hughes, Schurz, Nevada	10/17/63	10	14	<10	<10	<5	1.43	1.9
	10/24/63	10	14	<10	<10	85	1.43	1.8
	10/30/63	10	14	<10	<10	295	1.34	1.6
	02/01/64	<5	10	<10	<10	85	1.01	1.4
	03/31/64	30	64	<10	<10	375	1.42	
	05/05/64	<5	84	<10	<10	410		1.5
Zora Seitz, Schurz, Nevada	10/17/63	10	17	<10	<10	<5	1.32	1.9
Smith Creek Ranch, Nevada	10/17/63	5	18	<10	<10	55	1.36	2.1
	10/24/63	5	18	<10	<10	95	1.36	1.7
	11/01/63	10	24	<10	<10	120	1.29	1.8

Table 1. Milk sample analysis. (Cont.)

COLLECTION DATA		RADIOCHEMICAL DATA						
		ACTIVITY (pc l)					CONCENTRATION(gm l)	
LOCATION	DATE COLLECTED	Sr^{89}	Sr^{90}	I^{131}	Ba-La^{140}	Cs^{137}	Ca	K
Lyle DeBraga, Stillwater, Nevada	10/24/63	<5	32	<10	<10	125	1.40	1.2
	11/01/63	10	17	<10	<10	110	1.21	1.6
	01/30/64	5	6	<10	<10	45	1.27	1.6
	04/02/64	5	9	<10	<10	55	1.42	1.3

Table 2. Samples taken for Project Shoal.

SURVEILLANCE LOCATION	AIR Begin (1963)	AIR End (1964)	WATER Pre-Shot	WATER Post Shot	MILK Pre-Shot	MILK Post Shot	Film Badge Station Exposures
Alpine Ranch			2	1			
Austin	10/21	---	4	2	4	2	2
Brown Station			1	1	1	1	
Carroll Station			2	1			
Dixie Valley			2	2	2	2	1
Fallon	07/09	---	3	4	4	4	2
Frenchman Sta.	07/10	---		3			1
Gabbs	07/23	---	3	5	2	1	2
Hawthorne			3	2	2	3	1
Hot Springs			2	1			1
Ione			2	1	2	1	2
Lovelock	10/21	---		1			
Luning	07/23	01/31	2	1			2
Middlegate	09/12	01/31	2	1			2
Nev. Scheelite Mine	07/24	---	1	2			2
Peavine Ranch			2	1	6	11	
R.O. Inc. Ranch					2	1	
Schurz	07/09	---	2	1	3	4	2
Seyler Reservoir			1	1			
Smith Creek Ranch			2	1	2	1	
Stillwater			1	1	1	3	

NOTE: --- indicates sampling stations still in operation.

TECHNICAL REPORTS SCHEDULED FOR ISSUANCE BY AGENCIES PARTICIPATING IN PROJECT SHOAL

AEC REPORTS

Agency	Report No.	Project No.	Subject or Title
NBM	VUF-1001	33.2	Geological, Geophysical and Hydrological Investigations of the Sand Springs Range, Fairview Valley and Fourmile Flat, Churchill County, Nevada
SC	VUF-1002	40.5	Seismic Measurements at Sandia Stations
SC	VUF-1003	45.3	Hydrodynamic Yield Measurements
SC	VUF-1004	45.5	Device Support, Arming, Stemming and Yield Determination
SC	VUF-1005	45.6	Radiological Safety
EG&G	VUF-1006	60.4	Final Timing and Firing Report - Final Photo Report
USBM-PRC	*		Subsurface Fracturing From Shoal Nuclear Detonation
USWB	VUF-1008		Weather and Surface Radiation Prediction
USPHS	VUF-1009		Off-Site Surveillance
USBM	VUF-1010		Structural Survey of Private Mining Properties
USC&GS	VUF-1011		Seismic Safety Net
REECo	VUF-1012		On-Site Health and Safety Report

Agency	Report No.	Project No.	Subject or Title
RFB, Inc.	VUF-1013		Analysis of Shoal Data on Ground Motion and Containment
H-NSC	VUF-1014		Shoal Post-Shot Hydrologic Safety Report
H&N	VUF-1015		Pre-Shot and Post-Shot Structure Survey
H&N	VUF-1016		Test of Dribble-Type Structures
FAA	VUF-1017		Federal Aviation Agency Airspace Advisory

DOD REPORTS

	SC	VUF-2001	1.1	Free Field Earth Motions and Spalling Measurements in Granite
	SC	VUF-2002	1.2	Surface Motion Measurements Near Surface
**	USC&GS	VUF-2300	1.4	Strong Motion Seismic Measurements
	LPI	VUF-2600	1.6	In-Situ Stress in Granite
**	STL	VUF-2400	1.7	Shock Spectrum Measurements
	SRI	VUF-3001	7.5	Investigation of Visual and Photographic On-Site Techniques
	SRI	VUF-3002	7.6	Local Seismic Monitoring - Vela CLOUD GAP Program

TI	VUF-3003	7.8	Surface and Subsurface Radiation Studies
USGS	VUF-3004	7.9	Physical and Chemical Effects of the Shoal Event
ITEK	VUF-3005	7.10	Airborne Spectral Reconnaissance
BR Ltd.	VUF-3006	7.15	The Mercury Method of Identification and Location of Underground Nuclear Sites
NRDL	VUF-3007	7.16	Multi-Sensor Aerial Reconnaissance of an Underground Nuclear Detonation
GIMRADA	VUF-3008	7.17	Stereophotogrammetric Techniques for On-Site Inspection
ISOTOPES	VUF-3009	7.19	Detection in Surface Air of Gaseous Radionuclides from the Shoal Underground Detonation
*** USC&GS		8.1	Microearthquake Monitoring at the Shoal Site
**** GEO-TECH		8.4	Long-Range Seismic Measurements

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* This is a Technical Report to be issued as PNE-3001 which will receive TID-4500 category UC-35 Distribution "Nuclear Explosions-Peaceful Applications"

** Project Shoal results are combined with other events, therefore, this report will not be printed or distributed by DTIE

*** Report dated March 1964 has been published and distributed by USC&GS

**** Report dated December 9, 1963, DATDC Report 92, has been published and distributed by UED

LIST OF ABBREVIATIONS FOR TECHNICAL AGENCIES

BR Ltd.	Barringer Research Limited Rexdale, Ontario, Canada
EG&G	Edgerton, Germeshausen & Grier, Inc. Boston, Massachusetts Las Vegas, Nevada Santa Barbara, California
FAA	Federal Aviation Agency Los Angeles, California
GEO-TECH	Geo Technical Corporation Garland, Texas
GIMRADA	U. S. Army Geodesy, Intelligence and Mapping Research and Development Agency Fort Belvoir, Virginia
H-NSC	Hazleton-Nuclear Science Corporation Palo Alto, California
H&N, Inc.	Holmes & Narver, Inc. Los Angeles, California Las Vegas, Nevada
ISOTOPES	Isotopes, Inc. Westwood, New Jersey
ITEK	ITEK Corporation Palo Alto, California
LPI	Lucius Pitkin, Inc. New York, New York
NBM	Nevada Bureau of Mines University of Nevada, Reno, Nevada
NRDL	U. S. Naval Radiological Defense Laboratory San Francisco, California
REECo	Reynolds Electrical & Engineering Co., Inc. Las Vegas, Nevada
SC	Sandia Corporation Albuquerque, New Mexico
SRI	Stanford Research Institute Menlo Park, California

RFB, Inc.	R. F. Beers, Inc. Alexandria, Va.
STL	Space Technology Laboratories, Inc. Redondo Beach Park, California
TI	Texas Instruments, Inc. Dallas, Texas
USBM	U. S. Bureau of Mines Washington, 25, D. C.
USBM-PRC	U. S. Bureau of Mines Bartlesville Petroleum Research Center Bartlesville, Oklahoma
USC&GS	U. S. Coast and Geodetic Survey Las Vegas, Nevada
USGS	U. S. Geologic Survey Denver, Colorado
USPHS	U. S. Public Health Service Las Vegas, Nevada
USWB	U. S. Weather Bureau Las Vegas, Nevada